Research Requirements to Determine the Effects of Silvicultural Herbicides on Wildlife Habitat: a problem analysis

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EXECUTIVE SUMMARY

Forest vegetation management is done to assist the establishment and growth of conifer crop trees by reducing or suppressing competing plant species. Numerous options are available to forest land managers for controlling unwanted vegetation at various points in the rotation. The most commonly used are: one of several harvest systems, prescribed burning, mechanical treatments, timing of reforestation, use of appropriate planting stock, manual/motor-manual treatments, biological methods, and herbicides.

Several of these options will have some impact on wildlife habitat. However, this problem analysis primarily addresses the chemical, or herbicide option, because silvicultural herbicides have the potential for reducing available wildlife food sources and significantly altering wildlife habitats. As a result, additional information on how herbicides affect wildlife habitat is required to assist forest and wildlife managers in providing a range of habitats for various wildlife species, while meeting provincial silvicultural policy goals.

Stand Tending Records and published reports from the B.C. Ministry of Forests (MOF) were analyzed to obtain information on the extent of herbicide use in British Columbia. In general, these records show that herbicide use has increased in recent years and that:

1. glyphosate (Roundup®) and 2,4-D formulations are currently the most commonly used silvicultural herbicides for brushing and weeding, as well as for conifer release;
2. aerial spraying (an application method of greatest concern to provincial wildlife resource managers) has significantly increased; and
3. the Coastal Western Hemlock (CWH), Interior Cedar Hemlock (ICH), and the Sub-Boreal Spruce (SBS) biogeoclimatic zones have received greatest herbicide use.

Several integrated wildlife/forest research topics have been identified following a review of all available published information and consultation with wildlife and forest resource managers in the province and northwestern USA. These research topics are presented to assist resource managers in evaluating the effects of silvicultural herbicide treatments on the wildlife habitat resources. The topics in order of priority are:

1. an investigation of the response of moose browse to silvicultural herbicide treatments in the Sub-Boreal Spruce Zone;
2. the assessment of the impact of silvicultural herbicide treatments on grizzly bear forage resources in the Coastal Western Hemlock Zone, Engelmann Spruce-Subalpine Fir Zone, and/or the Interior Cedar Hemlock Zone;
3. the assessment of the impact of silvicultural herbicide treatments on Roosevelt elk browse in the Coastal Western Hemlock Zone;
4. the assessment of the impact of silvicultural herbicide treatments on small mammals and furbearers in the Sub-Boreal Spruce Zone, and the continuation of small mammal investigations conducted in 1986 (Coastal Western Hemlock Zone);
5. the assessment of the impact of silvicultural herbicide treatments on mule and while-tailed deer browse in the Interior Cedar Hemlock Zone; and
6. the assessment of the impacts of silvicultural herbicide treatments on forest bird habitat in the Coastal Douglas-fir or Coastal Western Hemlock Zone.

Additional research topics, such as an assessment of the impact of herbicide-induced changes to native grass important to ungulates and amphibians/reptiles, are also outlined. However, these are considered to be relatively less important than the six previously listed topics.

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1 INTRODUCTION AND PROJECT RATIONALE

Forest vegetation management is the science of manipulating unwanted vegetation and other environmental variables to suppress or alter the development of competing plant species, thus encouraging the growth and survival of crop trees. It is an important part of forest management in Canada, and the large areas of non-satisfactorily restocked (NSR) "backlog" forest land in British Columbia and elsewhere in Canada will require intensive vegetation management to bring them back into timber production (Sutton 1985).

The present and projected uses of forest vegetation management in the province have been described in a B.C. Ministry of Forests (MOF) problem analysis prepared by Conard (1984). This publication outlines several vegetation management options available to British Columbia forest resource managers for controlling unwanted plant species at various stages of the rotation. Conard's list of general vegetation management options include:

- choice of harvest (logging) system
- timing of reforestation activities
- selection of appropriate planting stock
- application of prescribed fire
- mechanical and/or manual methods
- planting of cover crops and use of mulches
- grazing of cattle and sheep
- herbicides

Undoubtedly, most of these techniques will change plant community structures, and possibly the forage and cover (habitat) resources used by the wildlife occupying the wide range of forest site types. However, only the herbicide option - - and specifically how the silvicultural herbicides affect wildlife habitat - - is the subject of this problem analysis. This decision was made for two reasons: it is likely that herbicides will play a large role in meeting future silvicultural objectives in British Columbia[1]; and wildlife and forest resource managers in the province require additional information on the impact of herbicide-induced changes to wildlife habitats, to ensure effective, integrated resource management.

The problem analysis provides background information on the extent of herbicide use in the province, and documents the concerns and information needs of professional wildlife and forest managers. It contains a review of existing technical literature and identifies several other potential research topics, ranked to reflect manager's needs.

Relatively few herbicides are registered for use in British Columbia forests compared to that in the Pacific Northwest United States. Of the limited number available to British Columbia silviculturalists for site preparation, conifer release, brushing and weeding, and other purposes, the following are most commonly used:

Common Name	Trade Name	Manufacturer
Glyphosate	Vision® (formerly Roundup®)	Monsanto
2,4-D	2,4-D amine and ester	various companies depending upon formulation
Hexazinone	Velpar®	Dupont, Pfizer

[1] Kimmins, J.P. and T. Simmons. 1980. Research needs into the use of herbicides in forestry in B.C. Unpublished report prepared for Forest Land use Liaison Committee of B.C.

The problem analysis begins with an outline in Section 2 of the methods used to obtain information on the subject. Section 3 provides background information on silvicultural herbicide use in the province; and section 4 summarizes the concerns and information needs of British Columbia wildlife and forest resource managers. The views of several American vegetation management specialists and wildlife ecologists, on the impact of herbicides on wildlife habitat, are also presented in this section. Existing vegetation monitoring programs and the potential for using monitoring data to measure impacts on wildlife habitat are discussed in Section 5. Section 6 contains a review of available literature. Several biological research topics are presented in Section 7. These topics are based on data gaps and information needs of British Columbia resource managers. Potential research topics have been ranked and the rationale used to determine research priorities is presented.

The Terms of Reference for this project were jointly prepared by the MOF, Research Branch, and the Canadian Forestry Service (CFS), with assistance from the B.C. Ministry of Environment (MOE), Wildlife Branch. The work was funded by the MOF and the CFS, under the Forest Resource Development Agreement (FRDA), Extension, Demonstration Research and Development (E, D, R & D) sub-program.

2 METHODS OF STUDY

Literature on the impact of silvicultural herbicides on wildlife habitats was reviewed as one of the first steps in the problem analysis. The present use of herbicides in the province for silvicultural purposes was determined, and concerns held by wildlife habitat biologists, forest resource managers, and other interested individuals and groups in the province were then documented. The final stage of the work involved identifying future biological research needs.

The literature review was undertaken and accomplished by several means. Individuals in British Columbia were canvassed for reports and articles, and resource specialists within and outside the province were contacted by telephone, by letter, or in person, regarding their knowledge of existing literature. Computer literature searches were also made to locate appropriate articles.

Data about silvicultural herbicide use in the province were obtained from the MOF's Stand Tending Records to February 23, 1987, and various MOF reports (Humphreys 1983, 1984, 1985). Data were classified by computer according to Forest Region, biogeoclimatic zone, year of use, chemical type, and method of treatment. The 1986 herbicide use data from the Stand Tending Records was, at the time of data gathering, incomplete. Therefore, summaries shown for that year, represent as only a partial data set.

The concerns and information needs of all MOE regional biologists, several forest managers, and selected public interest groups were determined through interviews and a questionnaire. The latter method of soliciting information and documenting concerns, although subjective, proved to be useful because the initial telephone contacts and questionnaire responses helped identify individuals for follow-up interviews and consultations. These follow-up meetings were held in Victoria, Smithers, Prince George, and Williams Lake.

One of the last tasks in data-gathering was a trip to Oregon and Washington to meet with vegetation management researchers, state and federal forest administrators, and other groups with information on the impacts of silvicultural herbicides on wildlife habitat in the Pacific Northwest. Appendix 1 provides a complete list of study contacts and their affiliations.

A progress report outlining work accomplished between May and August 1986 was submitted to the contract monitors for review in late August 1986. This report contained a preliminary list of research topics. The list was circulated to regional habitat biologists and specific reviewers in the MOF and the CFS for an initial review and comments. Mr. Terje Vold of the Wildlife Branch, MOE, and Mr. Rick Ellis of the Research Branch, MOF, were responsible for circulating the progress report and draft list of research topics to appropriate reviewers. Mr. Vold compiled the various reviewers' comments on behalf of the MOE and MOF.

A draft of the final report, submitted in September 1986, was reviewed by numerous MOE, MOF, and CFS personnel, as well as by selected forest industry and public interest group representatives. The report was revised between January and March 1987 in response to reviewers' comments and in accordance with modified Terms of Reference for the project prepared by MOF (Research Branch) and CFS.

3 SILVICULTURAL HERBICIDE USE IN BRITISH COLUMBIA

3.1 Introduction

This section contains background information on the use of silvicultural herbicides in British Columbia. It is intended to assist researchers in determining what locations are appropriate for future study on herbicide-induced wildlife habitat changes. The herbicide use information of most importance for this purpose includes:

1. identification of the biogeoclimatic zones of the province where herbicides have been most extensively used;
2. documentation of the types of herbicide most often used for operational forestry; and
3. identification of the main application methods.

This is not intended to be a definitive account of herbicide use in British Columbia, as such information is available in various government reports and computerized data files. Only data most germane to meeting the objectives of the problem analysis have been included here.

At the request of the MOF, Silviculture Branch, and the Canadian Forestry Service (M. Wyeth and W. Coombs, pers. comm., 1987), no projections of future herbicide use in the province were made. Future use will depend upon registration of new forest herbicides, treatment costs, the acceptability of using these chemicals in vegetation management programs, and several other variables.

3.2 Methods of Data Presentation

The use of silvicultural herbicides in British Columbia is documented in various formats by the MOF and the MOE, these include:

1. permits issued by the Pesticide Control Branch for silvicultural herbicide use ("use permits");
2. stand History Records, filed by MOF personnel;
3. stand Tending Records, filed by MOF personnel; and
4. provincial government summary reports of pesticide use from MOE Pesticide Control Branch files - - specifically those summaries of silvicultural herbicide use prepared by Humphreys (1983, 1984, 1985).

The Pesticide Control Branch records were considered inappropriate for this analysis because the use permits do not provide data on the actual area treated in any given year by biogeoclimatic zone. Permits issued by this agency often span more than 1 year, and the actual area treated by the permittee is generally less, on an area basis, than the total area designated on the pesticide use permit application (J. Henigman, pers. comm., 1987).

The Stand Tending Records provided by the MOF, Silviculture Branch, were used because this was the only data set available where use is recorded by biogeoclimatic zone. Stand Tending Records also distinguish between chemical and mechanical stand tending methods. This breakdown is not always apparent in the Stand History Records (M. Blackstock, pers. comm., 1987). Data contained in a summary of Stand Tending Records (referred to by the MOF as "Stand Tending Onetime Report 49") represent the total number of hectares annually treated in each MOF Forest Region and biogeoclimatic zone.

As mentioned in Section 2, the Stand Tending Records filed with the Silviculture Branch in Victoria are incomplete. Not only have the 1986/87 data not been compiled in the records, but some Forest Regions have not provided all stand tending data on a yearly basis to the Silviculture Branch in Victoria (M. Wyeth, pers. comm., 1987). Nevertheless, these records were used for this analysis because they represent the only summarized, centrally located source of data on the amount and type of herbicide use in the province, by biogeoclimatic zone (I. Kahn, pers. comm., 1987).

Stand Tending Record data were compiled using computer software sorting packages, and summarized by:

1. annual herbicide use by biogeoclimatic zone within each Forest Region;
2. total area by method of application (aerial, hack-and-squirt) within biogeoclimatic zones; and
3. total area by chemical type within biogeoclimatic zones.

Humphreys' reports (1983, 1984, 1985) were also used to provide additional information on the total area treated with herbicides for forestry purposes in the province, and total area treated with glyphosate and 2,4-D in the MOF Forest Regions.

3.3 Herbicide use in British Columbia based on Humphreys 1983, 1984, 1985

Figure 1 illustrates the total area (in hectares) treated with herbicides for forestry purposes in the province, between 1975 and 1985. The totals presented include all areas treated by the forest industry and the MOF, reported by the MOE Pesticide Control Branch. Since 1983, the total area treated with herbicides has doubled each year (6 181 ha in 1983; 14 131 ha in 1984; 27 151 ha in 1985). Glyphosate (Roundup®) and 2,4-D amine/ester were the two herbicides most commonly used by forest land managers in 1984 and 1985 (Glyphosate was registered for forestry use in 1984.)

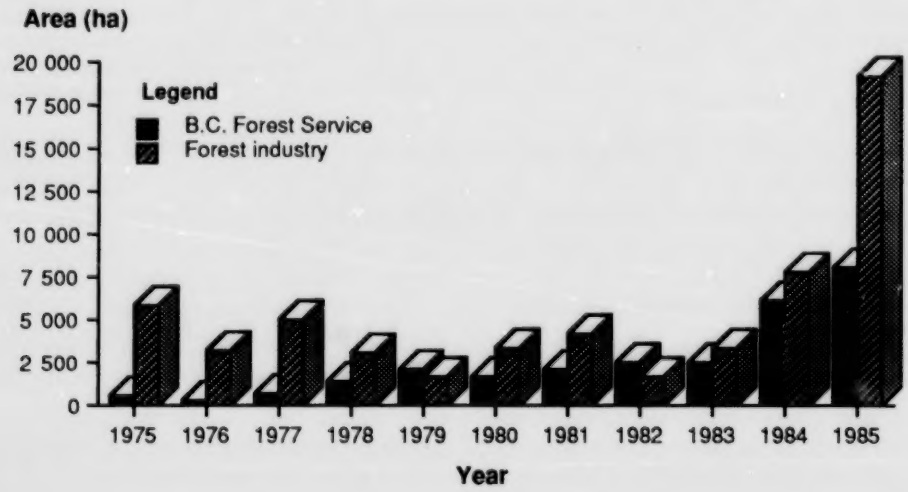

FIGURE 1. Total hectares of land treated with herbicides for forestry purposes, 1975 - 1985 (Source: Humphreys 1985.).

Table 1 illustrates the total hectares of land within MOF Forest Regions treated with glyphosate and 2,4-D amine/ester for the years 1983, 1984, and 1985 (total includes use for both industry and MOF, research and operational use). The table shows that the Vancouver and Prince George Forest Regions contained the largest area treated with the two herbicides within the six Forest Regions. The Prince George Forest Region has experienced the greatest increase in the use of these two herbicides over the 3-year period (1983-1985).

TABLE 1. Total hectares of land treated with glyphosate, 2,4-D amine/ester by MOF Forest Region (Source: Humphreys 1985)

MOF Forest Region	Glyphosate			2,4-D		
	1983	1984	1985	1983	1984	1985
		ha			ha	
Vancouver	239.4	4 512	5 811	4 050	5 256	5 254
P.Rupert	32	302	923	341	528	32
P.George	11.8	968	11 849	709	1 538	868
Nelson	1.2	222	689	101	145	0
Kamloops	0	3	457	0	0.5	0
Cariboo	0	0	0.8	0	0	0

3.4 Herbicide use in British Columbia based on Stand Tending Records

Table 2 summarizes the trade name, chemical name, and comments for each silvicultural herbicide existing in the Stand Tending Record data set for all Forest Regions.

Table 3 presents the total area of herbicide treatments in those biogeoclimatic zones of the province where herbicides have been used. The approximate total area of each biogeoclimatic zone and percentage of that area treated by herbicides are also included in the table to show the magnitude of herbicide use within each zone.

TABLE 2. Herbicides used for operational silviculture and research in British Columbia

Common Name	Trade Name	Comments
2,4-D	Many	Selective, phenoxy herbicide, with broad spectrum, systemic activity on broad-leaved weeds. Amine formulations are used for stem injection and cut stump applications; low volatile esters are preferred for foliar applications in water (or water and diesel) carrier. Ester formulations may also be applied to woody stems as a dormant oil treatment.
Glyphosate	Vision®, Roundup®	Relatively broad spectrum, systemic phosphonoalkyl herbicide, applied in water carrier to foliage or foliage or for stem injections and cut stump treatments.
Hexazinone	Velpar L®	Soil active, systemic triazine, applied directly to the soil as a concentrated spot treatment or in water carrier as a broadcast spray. Temporary registration for ground application only as of date of publishing.
Asulam	Asulox F®	Highly selective systemic carbamate, registered for control of bracken fern only. No longer produced for the forestry market.
MSMA	Glowon Liquid, Tree Killer®	Systemic arsonate, registered for pre-commercial thinning of conifer stands. Applied by stem injection. Also registered as an insecticide for control of bark beetles.

TABLE 3. Total area (ha) of herbicide treatments in specific biogeoclimatic zones (Source: MOF Stand Tending Record; Complete record to February 1987)

Zone	Area in B.C.[a] (ha)	Area treated in B.C.[b] (ha)	% of total zone treated
BWBS	20 500 000	1 027	.005
CDF	850 000	492	.058
CWH	4 500 000	18 303	.406
ESSF	11 800 000	425	.004
ICH	4 700 000	1 802	.038
IDF	4 800 000	427	.008
SBS	17 000 000	12 985	.076
MH	4 200 000	46	.002
TOTAL	68 350 000	36 019[c]	.052

[a] Source: Watts (1983).
[b] Source: MOF Stand Tending Records.
[c] Includes 512 ha unclassified in Stand Tending Records.

The Coastal Western Hemlock (CWH), Sub-Boreal Spruce (SBS), and Interior Cedar Hemlock (ICH) Biogeoclimatic Zones contain the largest number of treated hectares in comparison to the other five zones represented. The total area treated to date in British Columbia represents less than 0.1% of the total area of all biogeoclimatic zones represented.

Table 4 illustrates the total area of the various types of herbicide used in specific biogeoclimatic zones. The table lists all herbicides represented in the Stand Tending Records. It is noteworthy that some of these herbicides are not used operationally in British Columbia (see Table 2). Roundup® (glyphosate) and 2,4-D amine/ester were the most commonly used herbicides in the CWH, SBS, and ICH biogeoclimatic zones.

Figures 2 - 7 indicate the number of hectares within each Forest Region that have been treated annually with a silvicultural herbicide, by biogeoclimatic zone. Herbicide treatments without biogeoclimatic designations have been indicated to the right of the zone summaries in all figures. The Prince George, Vancouver, and Prince Rupert Forest Regions have the largest treated area of all six regions. The Cariboo and Nelson Regions have received substantially less herbicide treatment, and the Kamloops Region has a limited history of herbicide use (D. Piggin, pers. comm., 1987).

Trends in herbicide use within biogeoclimatic zones were identified according to chemical type and method of application. Figures 8 - 15 show the application method used in each biogeoclimatic zone, with an explanation of terms preceding the figures. Hack-and-squirt and aerial treatments are the most commonly used treatment methods. The former is extensively used in the SBS and CWH zones.

TABLE 4. Total area (ha) of chemical type used in specific biogeoclimatic zones (Source: MOF Stand Tending Records; complete record to February 1987)

Herbicide	ICH	ESSF	CDF	CWH	SBS	BWBS	IDH	MH	Unknown	Totals
Glyphosate	1 257.5	398.3	343.0	7 056.7	11 368.5	1 027.1	414.9	46.0	146.6	22 058.6
2,4-D	354.7	27.0	82.1	5 442.2	592.3	0 0	11.6	0.0	318.3	6 828.2
2,4-D amine	0.0	0.0	20.0	2 479.6	738.1	0.0	0.0	0.0	33.1	3 270.8
Fosamine ammonium[a]	0.0	0.0	44.6	3 128.4	0.0	0.0	0.0	0.0	14.0	3 187.0
Hexazinone	182.3	0.0	0.0	0.0	286.7	0.0	0.0	0.0	0.0	469.0
2,4-D ester	0.0	0.0	0.0	137.0	0.0	0.0	0.0	0.0	0.0	137.0
Picloram[b]	0.0	0.0	0.0	57.0	0.0	0.0	0.0	0.0	0.0	57.0
MSMA	7.6	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	9.2
Asulam	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
TOTALS	1 802.1	425.3	491.7	18 302.5	12 985.6	1 027.1	426.0	46.0	512.0	36 018.8

a Fosamine ammonium was used operationally under a temporary registration for forestry use as (Krenite®)in the early 1980's. No formulations of fosamine ammonium were registered for silvicultural use at this writing.

b Picloram (Tordon®) was used operationally, under the industrial registration, before a separate category for forestry registration was established. No formulations containing picloram were registered for silvicultural use at this writing. Tordon® is used for Knapweed control in British Columbia.

Explanation of terms used in Figures 8 - 15

Term	Explanation
Aerial application	Broadcast sprays from helicopter or fixed wing aircraft
Ground application	Broadcast or spot applications applied by ground-mounted sprayers, backpacks, spot-guns, or hand
Single stem treatments	Individual stem injection, hack-and-squirt or cut-stump treatments
Other	E.g., Pelletized formulations, dormant oil sprays
Unknown	Historical records do not include method of application

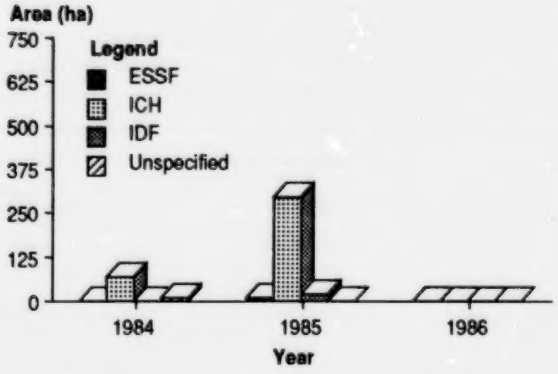

FIGURE 2. Area (ha) of silvicultural herbicide used in biogeoclimatic zones of the Kamloops Forest Region*.

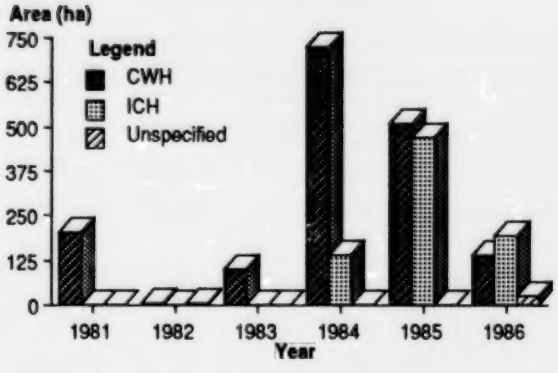

FIGURE 3. Area (ha) of silvicultural herbicide used in biogeoclimatic zones of the Prince Rupert Forest Region*.

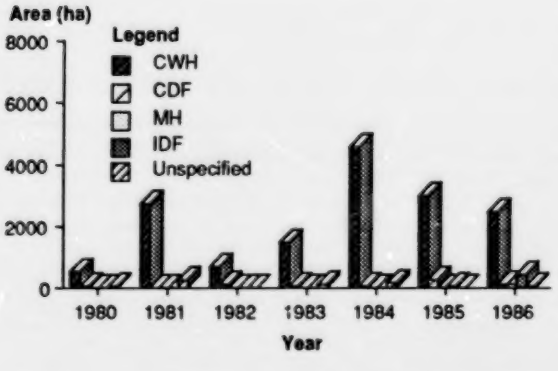

FIGURE 4. Area (ha) of silvicultural herbicide used in biogeoclimatic zones of the Vancouver Forest Region*.

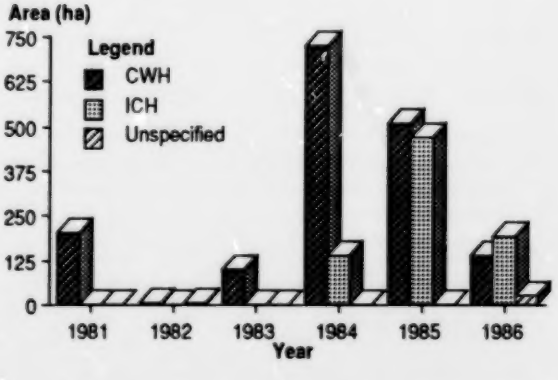

FIGURE 5. Area (ha) of silvicultural herbicide used in biogeoclimatic zones of the Nelson Forest Region*.

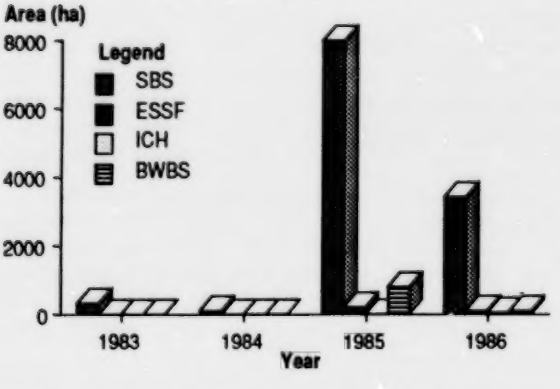

FIGURE 6. Area (ha) of silvicultural herbicide used in biogeoclimatic zones of the Prince George Forest Region*.

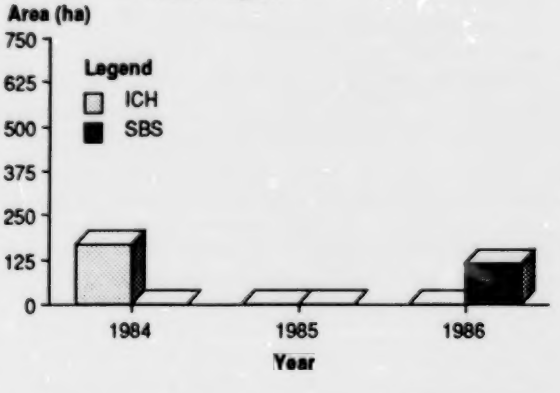

FIGURE 7. Area (ha) of silvicultural herbicide used in biogeoclimatic zones of the Cariboo Forest Region*.

*Note change in scale of Y-axis on Figures 4 and 6.

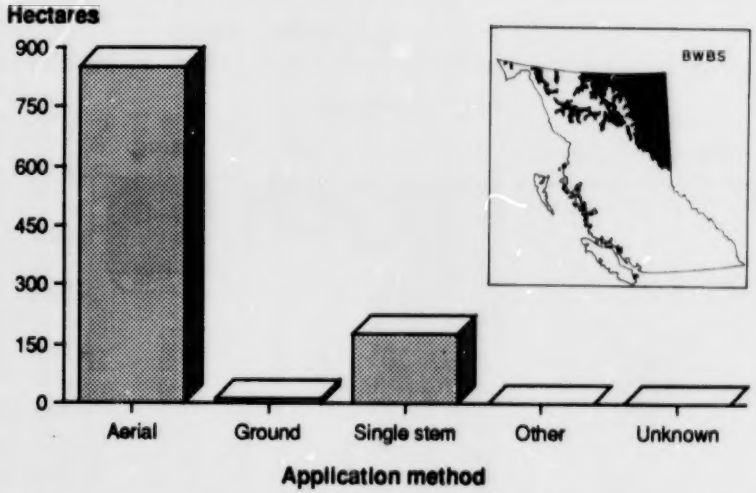

FIGURE 8. Area (ha) and method of herbicide application in the Boreal White and Black Spruce Zone*.

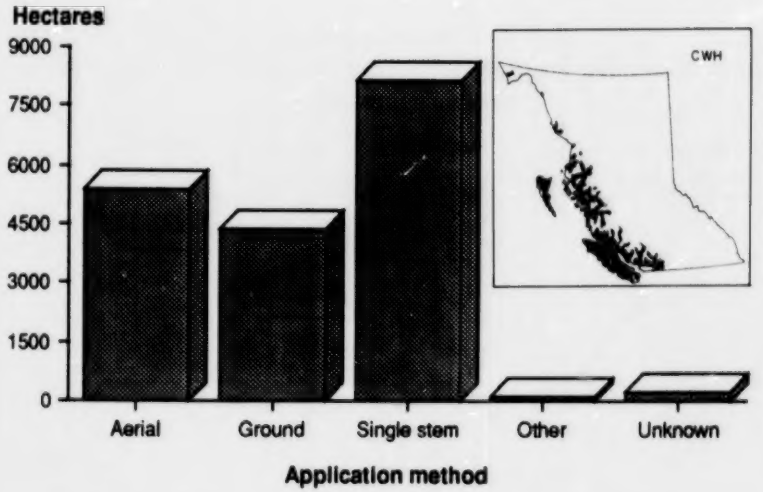

FIGURE 9. Area (ha) and method of herbicide application in the Coastal Western Hemlock Zone*.

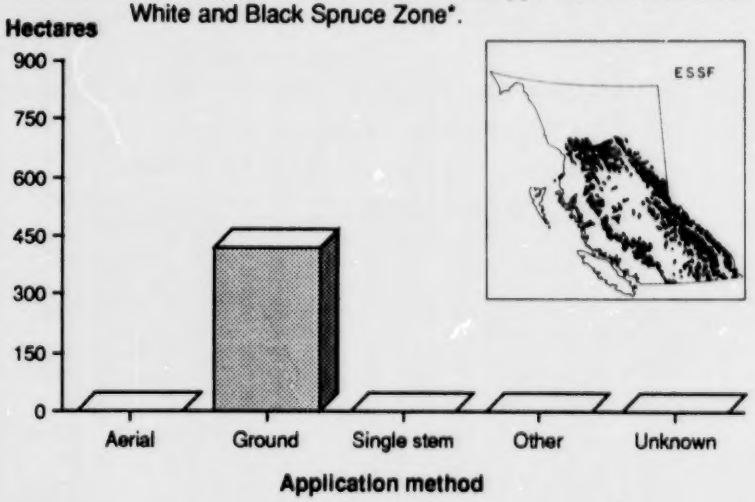

FIGURE 10. Area (ha) and method of herbicide application in the Engelmann Spruce – Subalpine Fir Zone*.

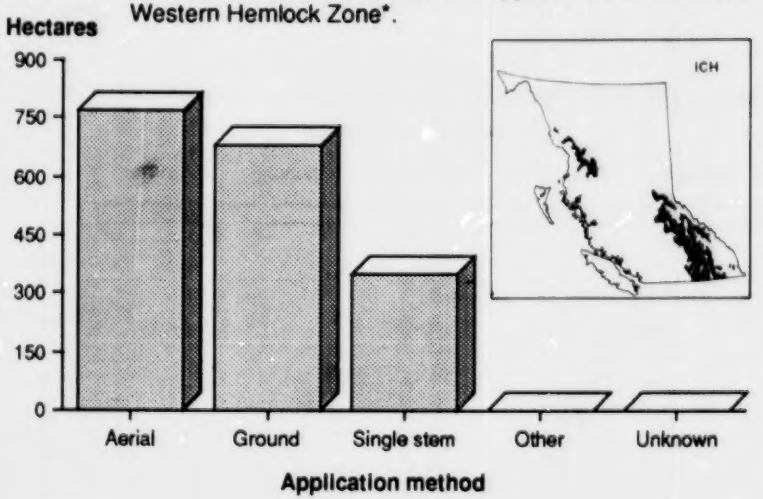

FIGURE 11. Area (ha) and method of herbicide application in the Interior Cedar – Hemlock Zone*.

*Note change in scale of Y-axis in Figures 9 and 14.

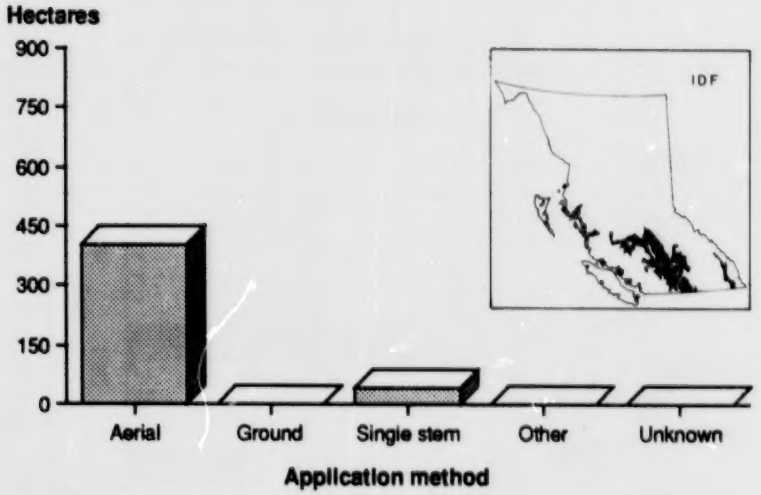

FIGURE 12. Area (ha) and method of herbicide application in the Douglas-fir Zone*.

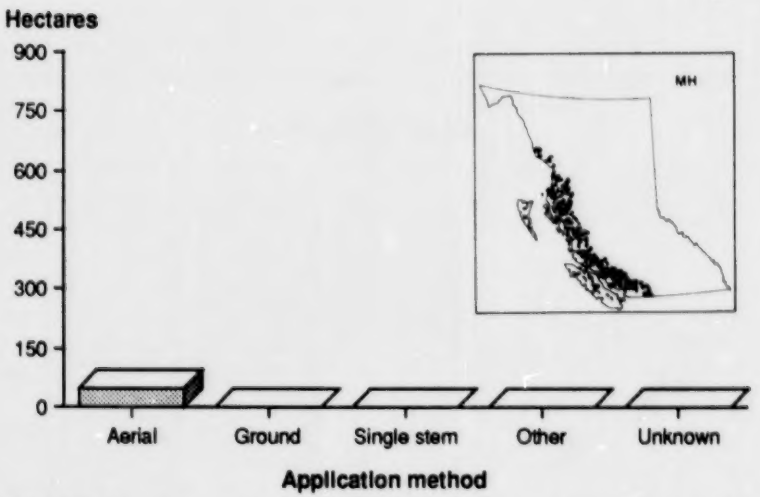

FIGURE 13. Area (ha) and method of herbicide application in the Mountain Hemlock Zone*.

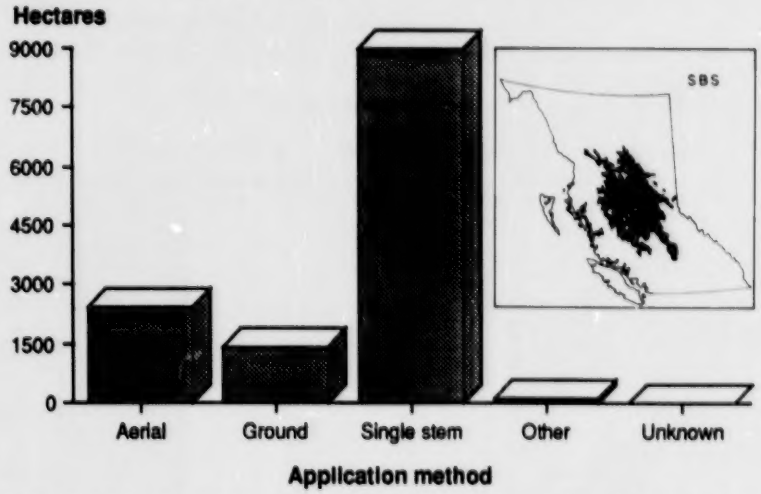

FIGURE 14. Area (ha) and method of herbicide application in the Sub-Boreal Spruce Zone*.

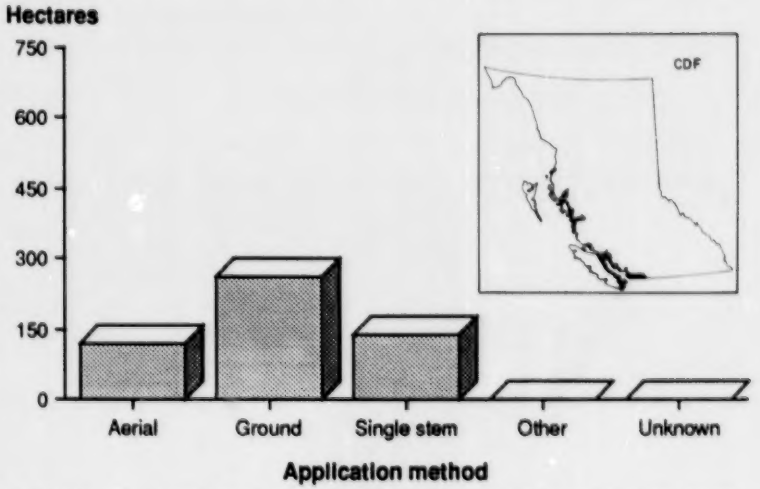

FIGURE 15. Area (ha) and method of herbicide application in the Coastal Douglas-fir Zone*.

*Note change in scale of Y-axis in Figures 9 and 14.

4. SUMMARY OF WILDLIFE HABITAT CONCERNS OF BRITISH COLUMBIA WILDLIFE AND FOREST RESOURCE MANAGERS

Several comments regarding the use and impacts of silvicultural herbicides in areas of importance to wildlife were documented during this investigation. The general concerns of wildlife and forest resource managers in British Columbia and of resource specialists in the Pacific Northwest are summarized below:

Wildlife habitat resource managers

- The potential reduction of forage and cover for game and non-game wildlife species, especially on winter ranges, riparian habitats, wetlands and other important habitats. The effects on wildlife of herbicide treatments have not been adequately assessed.
- The lack of transferability of some results from herbicide/wildlife research projects in the Pacific Northwest USA, to British Columbia.
- The lack of criteria on which decisions can be made regarding the use of herbicides in areas of known importance to wildlife.
- The short-and-long term effects of herbicide treatment on insects, an important food source for many non-game species, and on seed-and berry-producing plants.
- The lack of adequate ecological research into the effects of herbicide applications on the plant community structure and on individual plant species. There is also a lack of information about the suitability of areas after treatment to provide winter browse, cover, nesting sites, and forage for several wildlife species.
- The lack of documentation on long-term implications of altering early successional stages, and of selectively suppressing or altering the various phases of forest succession.
- The limited amount of integrated research between the MOF and MOE specifically on the subject of vegetation responses to herbicide treatments. For example, MOE Wildlife Branch Regional staff have reported that some of the herbicide trials done to date have not been detailed enough to provide data on the effect of herbicides on willows at a species level (B. van Drimmelin, pers. comm., 1986). Research that includes such data is required so that the effects of herbicides on preferred winter moose browse can be evaluated (since the various willow species are expected to respond differently to silvicultural herbicide treatments, and moose selectively browse certain species of willows).

Forest resource managers

- The lack of perspective in which herbicide use has been put. Herbicide use should be related to the total area of managed forest land in the province. M. Wyeth (pers. comm., 1986 and 1987) indicated that on average, 200 000 ha of mature and immature timber on Crown land are harvested or destroyed by wildfire each year. He, and other foresters, also suggested that the impacts of forest vegetation management activities on wildlife habitat be considered in the context of this annual addition and deletion of potential habitat.
- The inadequate information available from provincial wildlife managers on wildlife population levels and the habitat requirements of various key species. Once these estimates are available, it will be possible to determine whether or not the losses and alterations of wildlife habitat types caused by herbicide use are of biological importance. One industrial forester suggested that this analysis is perhaps best accomplished in a Timber Supply Area (TSA) analysis (R.P. Willington, pers. comm., 1987).
- The lack of research on the effects of silvicultural herbicides on wildlife habitat. Information is needed to resolve potential resource management conflicts in riparian and alluvial sites, which are usually both important wildlife habitats and locales of high site value.
- The major barrier to frank dialogue created by misconceptions of how forest chemicals are used. It was suggested that communications-oriented research is required immediately to improve

understanding among the public, wildlife managers, and forest managers. Particular emphasis should be placed on defining the role of herbicides in forest management and explaining why herbicides are used by silviculturalists as one of many available vegetation management tools (J. Mansell, pers.comm., 1987).

Pacific northwest resource specialists

Interviews with forest ecologists and wildlife and pesticide specialists from the Pacific Northwest underscored the need for additional detailed ecological research to assess the short- and, especially, long-term implications of herbicide treatments on the forest ecosystem. Most of these study contacts agreed that there may be some difficulty in applying research findings from one geographic area to another (M. Newton and D. deCalesta, pers. comm., 1986). However, virtually all Oregon and Washington State contacts (Appendix 1) expressed less concern about the impact of herbicides on wildlife and habitat, than did wildlife/habitat resource managers in British Columbia. Several U.S. experts interviewed also expressed concerns regarding the use of herbicides in riparian areas, and recommended that herbicides not be used in or near wet meadows and marshes. These contacts suggested that the potential for herbicides as a habitat enhancement tool be given additional future research consideration (G. Larsen, D. deCalesta, M. Newton, D. Perry, and S. Conard, pers. comm., 1986). The need to compare the impact of herbicide treatments to that of alternative vegetation management strategies, including that that no treatment, was also identified because if implemented, any of the strategies also cause changes to wildlife forage and cover habitat resources.

The Cooperative Wildlife Research Unit and the Forest Research Laboratory at Oregon State University (OSU) have done the most research on the impact of silvicultural herbicides on wildlife. Of all agencies contacted during this investigation, the primary concerns of OSU experts appeared to be related to how, when and where herbicides should be applied to maintain a diversity of habitat types on managed lands, rather than to whether herbicides should be used. All of the forest ecologists contacted at OSU view herbicides as one of many vegetation management options available for providing a range of wildlife habitats while meeting silvicultural policy goals objectives (M. Newton, D. deCalesta, D. Moore, S. Radosevich, and D. Perry, pers. comm., 1986).

5 VEGETATION MONITORING IN RELATION TO WILDLIFE HABITAT MANAGEMENT: A REVIEW OF CURRENT ACTIVITIES

Information on the current use of vegetation monitoring for determining herbicide-induced changes to wildlife habitat was gathered through interviews. These were conducted not only in person in British Columbia, but also by mail and telephone with other jurisdictions bordering British Columbia.

The results of this survey showed that no operational or rigorous, systematic monitoring trials have been undertaken to document herbicide-induced habitat changes in the Yukon, Alaska, Alberta, Idaho, Washington, or Oregon.

The MOF is currently conducting herbicide research and developing vegetation management systems. The scope of these research trials is discussed in two reports: 1) Level A Trials (Pollack and Herring 1985); 2) Level B Trials (Herring and Pollack 1985). These trials are designed to investigate various vegetation management systems and techniques for establishing and maintaining commercial tree growth. Consequently, the research is not suitable for adequately monitoring habitat changes or determining impacts of herbicide treatments on wildlife and wildlife habitat. However, it is believed that much of the data and results may be of value to wildlife biologists.

The recently published *Guidelines for Monitoring Habitat Improvement* (Pedology Consultants 1986) is currently being tested for use in British Columbia to monitor habitat-induced changes resulting from herbicide treatments.

It provides standard methods and terms for use in collecting data related to the documentation and monitoring of a wide variety of wildlife habitat and range management techniques. One of the habitat management techniques discussed was the use of herbicides to alter a plant community, such that plant species considered desirable as food or shelter habitat for domestic stock or wildlife could be enhanced.

The MOE Wildlife Branch and MOF Range Management Branch, felt this handbook and the data collection forms were acceptable, with some modifications, for monitoring vegetation and documenting ecological site characteristics in the context of the silvicultural use of herbicides. Their use for monitoring herbicide treatment sites is now being considered by the MOF, although it has not formally endorsed their use.

This data collection system has been used for one field season, and is currently being revised by the MOE Wildlife Branch and the MOF Range Management Branch.

The Pesticide Control Act and Regulations(1978) is administered by the MOE Pesticide Control Branch (PCB). This branch is the central government agency controlling the use of herbicides in British Columbia. Through regulation, the PCB requires persons intending to apply herbicides to publicly owned land or land used for forestry to obtain a permit. The application made by the proponent for a pesticide or herbicide use permit is assessed by the PCB and a review committee, which includes representatives from the MOE Wildlife Branch and Fisheries Branch. Regional offices of the PCB enforce the regulations of the Pesticide Control Act and occasionally inspect conditions of use.

As stated previously, no other agencies or jurisdictions outside British Columbia that Westland contracted are currently monitoring vegetation to determine the impacts of herbicides on wildlife habitat. While each of the adjacent jurisdictions has specific regulations for the use of silvicultural herbicides, these regulations are mainly oriented to fisheries and human health concerns - - not to wildlife habitat issues. However, most agency staff of these jurisdictions indicated an interest in the protection of wildlife habitat resources and expressed interest in being kept informed on the use of monitoring techniques being developed in British Columbia.

6 REVIEW OF EXISTING LITERATURE AND DISCUSSION OF FINDINGS

6.1 Introduction

A review of the literature on the impact of silvicultural herbicide treatments on wildlife and wildlife habitat produced few comprehensive herbicide/wildlife habitat investigations.

A complete list of publications reviewed is presented in the Literature Cited section. Those considered to be most useful for future habitat and wildlife investigations in British Columbia have been highlighted with an asterisk.

The Cooperative Wildlife Research Unit and Forest Research Laboratory at OSU, as well as other research facilities in Oregon, are currently at the forefront of this type of research. Although certain inferences can be drawn from coastal Oregon studies, not all of the findings of the herbicide/wildlife studies done in the Pacific Northwest, elsewhere in the USA, or Canada are applicable to British Columbia because of climatic differences, dissimilar vegetation types, and other variables (M. Newton, and D. deCalesta, pers. comm., 1986).

In general, game species have received most of the herbicide/ wildlife research effort to date. Ungulates have been the most frequently studied species group, although small mammal investigations have been done in Oregon (Anthony and Morrison 1985) and in British Columbia (Sullivan and Sullivan 1981, and 1982). Another coastal British Columbia study of the effects of glyphosate on small mammals was conducted on Vancouver Island in 1986 for the B.C. Trappers Association, MOE Wildlife Branch, and Simon Fraser University.[2]

Bird use of herbicide-treated clearcuts has been investigated in western Oregon, but no similar avian studies have been conducted in British Columbia. Overall, ecological studies that include assessments of the effect of herbicide-induced changes to invertebrate and vertebrate food resources of furbearers, game, and non-game wildlife species (other than ungulates and small mammals) are extremely limited.

The lack of adequate wildlife research in British Columbia is perhaps not surprising considering the relatively low use levels in the past and limited use history of silvicultural herbicides in the province.

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[2] Ritchie, C.D., AS. Harestad, and R. Archibald. 1988. Glyphosate treatment and small mammal abudnance. Unpubl. rep. 20 p.

Because of the significant increase in herbicide use in recent years, the research concerns related to wildlife have gained much more recognition.

Morrison and Meslow (1983) and Newton *et al.* (in press) contend that the structure and composition of vegetation are primary factors governing the abundance and distribution of wildlife. It follows, then, that changing the vegetation by shortening the successional brush stage and effectively suppressing competing vegetation long enough to allow conifers to gain dominance ought to result in short-and long-term changes in wildlife use. The complete assessment of the impact of any vegetation management practice on wildlife is possible only if the relationships between wildlife and habitat are known. These relationships are currently being documented through the B.C. Wildlife Handbook program. This cooperative project of the MOE and MOF aims to develop planning tools to help wildlife habitat and forest resource managers make better use of the indirect habitat management opportunities afforded by timber harvesting, forest vegetation management practices, and other non-forestry resource activities such as surface mining (Harcombe 1984). The B.C. Wildlife Habitat Handbooks will provide state-of-the-art knowledge about the value of shrub/seedling stages for over 100 game and non-game wildlife species (A. Harcombe, pers. comm., 1986).

6.2. Ungulates

Most of the studies reviewed were conducted in the coastal forests of Oregon, Washington, and British Columbia. Black-tailed deer have received the most study because they are one of the most important and visible game species in these coastal forests, and because they use the deciduous trees, shrubs, and herbs that compete with commercial conifers in clearcuts and selectively logged lands. However, none of the wildlife studies reviewed adequately addressed winter range issues or the impact of herbicide treatments on ungulate forage resources in various seasons of the year.

Through studies of black-tailed deer habitat use and food preference, Sullivan (1985) and Newton and Norris (1968) found that deer will remain in herbicide-treated habitats and will consume glyphosate-treated foliage. However, the long-term effect on deer and other wildlife species consuming glyphosate-treated foliage is not known (D. deCalesta, pers. comm., 1986).

Damage to Douglas-fir and pine seedlings from browsing by black-tailed deer and elk, and from insects, small mammals, bears, and other wildlife species is considered to be a major problem by forest managers in western Washington and Oregon (Barnes 1973; Campbell 1974; Campbell and Evans 1975). Therefore, much of the forest plantation, herbicide, and wildlife research done to date in the Pacific Northwest has focussed on ways to reduce wildlife damage to conifer seedlings. These investigations have little value in assessing the impact of herbicides on wildlife and habitat.

The availability of deer and moose browse following glyphosate and triclopyr treatments for conifer release in the spruce-fir forests of Maine was investigated by Newton *et al.* (in press). One of the few long-term studies done, revealed that herbicides reduced the availability of winter browse in cut-over forested land for 2 years following treatment. However, at least in the 7 years after this reduction, the availability of woody browse lower than 2.5 m in height, and therefore within reach for deer and moose, was 4 - 8 times higher in the treatment areas than the control. Nearly all browse species present before the herbicide treatment were found to be present for at least 9 years following the initial 1 - 2 years of browse suppression.

Researchers concluded that if this initial impact of browse reduction can be ameliorated by locating treatment areas within or adjacent to untreated areas (i.e., staggering treatments to provide interim browse or untreated sites), and if the released conifers are spaced to the widest spacing consistent with conifer volume growth, then herbicides will facilitate the growth of a longer lasting, desirable, browse/shrub community. M. Newton (pers. comm., 1986) suggests that both wildlife and forest managers should consider using herbicides, especially glyphosate, to improve browse conditions for deer and moose. This may have the additional benefit of reducing wildlife damage to conifer seedlings and immature trees within a plantation.

A similar but shorter-term study of the effect of 2,4-D and glyphosate on moose browse in forest plantations of Minnesota has been done by Kennedy and Jordan (1985). This research revealed that even though a relatively small portion of the total forest land base is treated with herbicides, the areas treated are typically favoured moose feeding areas as well. Kennedy and Jordan found that conifer release treatments using 2,4-D temporarily reduced total browse, but did not appear to reduce carrying

capacity for moose. Their preliminary findings indicate that little resprouting occurs in glyphosate-treated moose browse compared to that treated with 2,4-D. For this reason, glyphosate treatments are believed to have the potential of reducing carrying capacity in forest plantations of northeastern Minnesota because, by the time woody plants re-establish, the conifer canopy is almost closed.

A 3 year investigation initiated near Thunder Bay, Ont., in 1986, is studying the impact of glyphosate, used operationally for conifer release, on the vegetative composition, density, and winter utilization of treatment areas by moose, snowshoe hare, and small mammal populations. The study is a co-operative venture of the Ontario Ministry of Natural Resources, Wildlife and Forest Resources Branch staff.

Data collected during the 1985/86 pilot year of the project indicate that there was no statistical difference in browse stem density between the control and treatment sites. As well, there was no apparent difference in moose utilization (i.e., no preference for treatment or control sites) within a 4 - to 7-month period following the aerial application of glyphosate (Timmerman *et al.* 1986). According to one of the authors of this report (Krishka), these results indicate a low impact - - that is, minimal differences between moose utilization of treated and untreated cut-blocks. She does, however, caution that it is too early in the study to draw any conclusions.

The efficacy, or effectiveness, of registered herbicides in eradicating or controlling various plant species that compete with crop trees in British Columbia, has been rated by Coates and Haeussler (1986). Information on the effects of silvicultural herbicides on important wildlife forage species has also been summarized in a draft report to the MOE Wildlife Branch[3]. This report reviews the results of numerous herbicide trials from British Columbia, the prairie provinces, and northwestern United States, and of abstracts prepared by the Expert Committee on Weeds. In it are summary tables documenting the response of forage plant species to herbicide use, by chemical type, method of application, dosage rate, and season of application.

Information from the Coates and Haeussler (1986) and MOE reports have been used to prepare Tables 5-8. These tables outline the relative susceptibility of important moose, Rocky Mountain elk, Roosevelt elk, and deer winter browse species to three silvicultural herbicides registered for use in British Columbia forests.

6.3 Small Mammals

Several studies on the effects of herbicide treatments on small mammals have been carried out, as this species group is expected to be sensitive to herbicide-induced habitat changes because they are less mobile than birds and large mammals. Study attention has also focussed on small mammals because of their importance as a food source for avian and terrestrial predators such as raptorial birds and furbearers.

The literature review revealed that all vegetation management practices, including herbicide treatments, will alter both food and cover resources available to small mammals. The degree to which small mammal species composition, density, and abundance is affected appears to depend upon what vegetation type is being controlled. The timing and type of vegetation management practice are also expected to have an impact on these factors (Perry and Tappeiner 1986).

Sullivan and Sullivan (1982) and Ritchie *et al.* [4] investigated the effect of glyphosate use on small mammals in coastal British Columbia forests. The Sullivans' study reports no significant difference in population density of deer mice following a Roundup® treatment of a 20-year-old plantation. Ritchie *et al.* found deer mice to be more abundant on untreated clearcuts than on treated clearcuts, but deer mice were more abundant in neighbouring old-growth forest stands than in either of the clearcut areas. They suggest that the conflicting results may be due in part to the fact that the Sullivans' work was done at a more advanced successional stage, and that surviving coniferous trees in the treatment areas may have provided sufficient residual cover to ameliorate the loss of deciduous cover caused by the herbicide treatment. The Ritchie *et al.* investigation was a preliminary study, and the results should be judged accordingly (D. Eastman, pers. comm., 1986).

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[3] Balfour, P. (1988). The effects of forest herbicides on B.C. ungulates and grizzly bear forage species. Tech. summary. B.C. Ministry Environment Parks, Wildlife Branch, Victoria, B.C. In preparation.

[4] Ritchie et al., 1988

Borrecco (1972) and Borrecco *et al.* (1972) investigated the effect of herbicides on small mammals at three sites, two in the western Cascade Mountains and one site in the eastern portion of the coast range of Oregon. All sites were dominated by grasses and forbs and each were burned between 8 and 12 years prior to the study. The herbicide treatment caused a shift in vegetation from a grass-forb habitat type to an Oregon-grape and trailing blackberry, or low shrub dominant habitat type. Deer mouse and Trowbridge shrew (*Sorex trowbridgii)* populations increased on treated areas, likely because preferred food and suitable cover resources were available for both species. Conversely, populations of herbivorous small mammal species and those species requiring habitats dominated by grasses such as the Oregon vole (*Microtus oregoni)*, jumping mouse *(Zapus trinotatus)*, and vagrant shrew *(Sorex vagrans)* were reduced on treated areas compared to the adjacent control. In a study of the effect of glyphosate on small mammal distribution and density in habitats of western Oregon, Anthony and Morrison (1985) found that the herbicide reduced shrub cover and caused a 1 year increase in grass and forb cover under the treated vegetation. Oregon vole population densities increased on these sites 1 year after the treatment, in response to the habitat change. This population increase was temporary, with the abundance of voles returning to approximately pre-treatment levels 2 years after spraying. The authors found the number of other small mammal species to be unaffected by treatment.

Abbreviations used in Tables 5 - 8.

NAI	No information available.	V	Variable susceptibility (variable response and control).
L	Low susceptibility (poor or no control of plant by chemical).	H	High susceptibility (good control).
M	Moderate susceptibility (moderate control).	VH	Very high susceptibility (excellent control).

TABLE 5. Relative susceptibility of moose winter browse to herbicide treatment[a]

Plant Species[b]			Susceptibility of plant to:		
Common name	Scientific name	Browse importance rating[c]	2,4-D	Roundup®	Velpar®[d]
Willows(s)	*Salix spp.*	high	V–M	L–H	M–H
Paper birch	*Betula papyrifera*	med. – high	M–H	M–H	V
Rocky mtn. (Douglas) maple	*Acer glabrum*	med.	M	H	NAI
Highbrush cranberry	*Viburnum edule*	med.	NAI	M–H	M
Red osier dogwood	*Cornus sericea*	med.	L–M	L–M	M
Trembling aspen	*Populus tremuloides*	med.	V–H	H	H

[a] Source: Coates and Haeussler (1986); Balfour (ibid.).

[b] Several other plant species are known to be important to moose as winter browse. However, no data are available on the susceptibility of many of these plants to silvicultural herbicides.

[c] Source: D. Blower. (1982). Key winter forage plants of B.C. ungulates. Fish and Wildlife Branch. Unpubl. memo; and J. Singleton. 1976. Food habits of wild ungulates in B.C. Unpubl. rep. of the B.C. Environ. and Land Use Committee Secretariat and Fish and Wildl. Branch.

[d] Plant response is variable depending on soil characteristics. For example, Velpar is ineffective on vegetation growing on organic soils (W. Coombs, pers. comm. 1987).

TABLE 6. Relative susceptibility of Rocky Mountain elk winter browse to herbicide treatment[a]

Plant Species[b]			Susceptibility of plant to:		
Common name	Scientific name	Browse importance rating[c]	2,4-D	Roundup®	Velpar®
Rocky Mtn. (Douglas) Maple	*Acer glabrum*	mod.	M	H	NAI
Red osier dogwood	*Cornus sericea*	mod.	L–M	L–M	M
Trembling aspen	*Populus tremuloides*	mod.	V–H	H	H
Willow (s)	*Salix spp.*	mod.	V–M	L–H	M–H

[a] Source: Coates and Haeussler (1986); Balfour (Ibid.).
[b] Several other plant species are known to be important to Rocky Mountain elk as winter browse. However, no data are available on the susceptibility of many of these plants to silvicultural herbicides.
[c] Source: Blower (Ibid.); Singleton (Ibid.)

TABLE 7. Relative susceptibility of Roosevelt elk browse to herbicide treatment[a]

Plant Species[b]			Susceptibility of plant to:		
Common name	Scientific name	Browse importance rating[c]	2,4-D	Roundup®	Velpar®
Salmonberry	*Rubus spectabilis*	high	L–M	VH	L
Willow(s)	*Salix spp.*	mod.	V–M	L–H	M–H
Elderberry	*Sambucus racemosa*	high	L–V	L–H	NAI
Blueberries and huckleberries	*Vaccinium spp.*	mod.	M	V	NAI

[a] Source: Coates and Haeussler (1986); Balfour (Ibid.)
[b] Several other plant species are known to be important as Roosevelt elk as winter browse. However, no data are available on the susceptibility of many of these plants to silvicultural herbicides.
[c] Source: Blower (Ibid.); Singleton (Ibid.)

6.4 Birds

Forest bird community structure, is influenced by the successional stage of the vegetation. Early successional stages, because of great plant species diversity and variable height classes, provide highly diverse habitats, and therefore receive the highest bird use of any forest environment. The effects of 2,4-D on bird communities have been investigated, and the general finding of all the studies was an alteration of bird densities in the herbicide-treated area (Slagsvold 1977; Beaver 1976; Savidge 1978). These

studies did not directly relate changes in density of birds to changes in habitat use, but relied solely upon changes in density to infer treatment effects.

TABLE 8. Relative susceptibility of mule, black-tailed deer and white-tailed deer browse to herbicide treatment[a]

Plant Species[b]			Susceptibility of plant to:		
Common name	Scientific name	Browse importance rating[c]	2,4-D	Roundup®	Velpar®
Salal	*Gaultheria shallon*	high	L	L	NAI
Maple	*Acer sp.*	mod.high	L–M	V–H	NAI
Blueberry	*Vaccinium spp.*	mod.high	M	M	NAI
Red-osier dogwood	*Comus sericea*	mod.	L–M	L–M	M
Sword fern	*Polystichum*	mod.	L–M	V–H	M
Currants/ gooseberries	*Ribes spp.*	mod.	M	M–H	NAI
Thimbleberry	*Rubus parviflorus*	mod.	L–M	V–H	L–M
Salmonberry	*Rubus spectabilis*	mod.	L–M	V–H	NAI
Willow(s)	*Salix spp.*	mod.	V–M	L–H	M–H
Elderberry	*Sambucus racemosa*	mod.	L–V	L–H	NAI
Snowberry	Symphori carpus spp.	mod.	H	H	H

[a] Source: Coates and Haeussler (1986); Balfour ((Ibid.)
[b] Several other plant species are known to be important to deer as winter browse. However, no data are available on the susceptibility of many of these plants to silvicultural herbicides.
[c] Source: Blower (Ibid.); Singleton (Ibid.)

This research problem was overcome by Morrison and Meslow (1984a) in their investigations of the effect of 2,4-D, 2,4,5-T, and glyphosate on bird communities in cut-over land in Oregon. These are believed to be the most complete avian/herbicide investigations available, the findings of which have been summarized by Perry and Tappeiner (1986) as follows:

> Morrison and Meslow (1984a) compared bird communities between sprayed (2,4-D or 2,4,5-T) and unsprayed clearcuts on the Hebo and Alsea Districts of the Siuslaw National Forest in Western Oregon. They looked at two stages of development, (a) four to five years after planting and one year after spraying, and (b) six to eight years after planting and four years after spraying. All sites were 225 to 400 m in elevation and on generally north aspects; primary vegetation on unsprayed sites was salmonberry, thimbleberry, vine maple, salal, and red alder.

On sites sprayed one year previously, cover of vegetation greater than 3 m in height was 3 percent, compared to 10 percent on unsprayed controls. This difference persisted in the sites sprayed four years previously. Sprayed and unsprayed areas did not differ in total density or diversity of birds, however there were shifts in species composition. One year from spraying average densities of willow flycatcher, American goldfinch, Swainson's thrush, orange crowned warblers, rufous sided towhees and dark-eyed junco's were lower on sprayed than on unsprayed areas, while the opposite was true of rufous hummingbirds. None of these differences were significant at the .05 level, however. By four years after spraying statistically significant differences had developed - with towhees, juncos, hummingbirds, and Wilson's warblers more numerous on unsprayed sites, and the white crowned sparrow more abundant on sprayed sites. Despite these differences, total diversity and density of birds were nearly identical between sprayed and unsprayed areas.

In this study there were noticeable shifts in bird use of various vegetation layers following spraying. Spraying reduced alder cover, while shrubs quickly recovered from initial defoliation. Increased use of shrubs by Wilson's warbler and Swainson's thrush was in response to reduction of the alder, their primary foraging substrate. However, this compensatory behaviour was not enough to maintain densities of these species, which were 2 or 3 times lower on sprayed than on unsprayed sites. In contrast, the white-crowned sparrow avoids hardwood trees and dense shrub cover, and is therefore more abundant on sprayed areas. One year from spraying all warbler species foraged more in shrubs on sprayed than on unsprayed areas, and juncos, sparrows, hummingbirds, and MacGillivray's warblers increased their use of hardwood trees on sprayed sites. Four years after spraying, Swainson's thrush and Wilson's warbler still used shrubs relatively more on sprayed areas. However, hummingbirds, MacGillivray's warblers, towhees, and white-crowned sparrows used them less. These use patterns indicate that birds are able to adapt their feeding behaviour, to some degree, in response to changes in vegetative composition. Morrison and Meslow (1984a) conclude that maintenance of a relatively small cover of deciduous trees is important in stabilizing bird communities.

In a second study, Morrison and Meslow (1984b) investigated the effect of glyphosate on bird communities in the Coast Range. Because glyphosate controls common shrubs *(Rubus spp.)* more effectively than do phenoxy herbicides such as 2,4-D, it might be expected to also affect the bird community differently. As in their previous study of phenoxy herbicides, Morrison and Meslow found no change in total density and diversity of birds following spray, although there were shifts in species composition. Those using shrubs for both foraging and nesting declined in numbers in the 1st year following spray, and there was also a shift in substrate use by some species. In the 2nd year post-spray, shrubs had vigorously recovered, and the bird use also increased. Species that had decreased in number in the 1st year after spraying increased in the 2nd year, sometimes dramatically. MacGillivray's warbler, for example, was 4 times more abundant in the 2nd than in the 1st year after treatment. In contrast, species that increased in the 1st year, such as the American goldfinch and willow flycatcher, decreased in the 2nd year.

6.5 Summary

The literature revealed a complete lack of research on the impact of herbicides on the habitat and food resources of grizzly bear, black bear, raptorial birds, upland game birds, or species other than those outlined previously. Several of the small mammal studies reported that an objective of the research was to determine the potential impacts of herbicide-induced habitat/prey changes on furbearing mammals and raptors. However, no assessments of these impacts were found in the literature review.

In general, extant bird and mammal studies have demonstrated that all wildlife species respond to changes in habitat, and appear to have an ability to adapt to habitat alteration, at least in the short term. A limited number of wildlife studies reveal that the temporary reduction of competing vegetation on a given site by herbicides or other vegetation management techniques is tolerable by wildlife as long as there is an adjacent source of vegetation available to colonize the treatment area, and a diversity of habitats are maintained in the surrounding area. This view was shared by most of the ecologists interviewed (e.g. D. deCalesta, D. Perry, and M. Newton, pers. comm., 1986). Morrison and Meslow (1983) suggest that the initial impact of clearcutting has a far greater influence on wildlife than does any follow-up treatment. They further suggest that the response of wildlife to the entire range of forest management practices (i.e., not only to a single treatment), be considered, to put the issue of silvicultural herbicide use in proper perspective.

7 RANKED LIST AND RATIONALE FOR FUTURE WILDLIFE HABITAT RESEARCH

7.1 Introduction

In general, knowledge on the ecological impacts of herbicides and other methods of forest vegetation management in British Columbia is limited. The need of research on a broad range of wildlife and forest resource topics has been identified by Conard (1984), Kimmins and Simmons[5], and others. These research efforts should provide data on issues of interest to resource managers in the MOE Wildlife Branch, the MOF Silviculture, Range Management, Protection and Research Branches, the CFS, the Canadian Wildlife Service (CWS), and the forest industry.

The following general ecological research subject areas were identified in this report, based on an assessment of the adequacy of existing knowledge:

- ungulate browse research
- grizzly bear forage research
- small mammal and furbearing mammal research
- forest bird habitat research
- amphibian and reptile research

Several specific research topics within these general subject areas were delineated through discussions with regional and headquarters staff of the MOF, CWS, and the MOE. Potential research topics were also identified following the review of written responses to the August 1986 progress report.

Project contract monitors requested that the various potential biological research topics be ranked in order of priority. The ranking system used is designed to reflect both the likelihood of habitat alteration due to herbicide treatment within frequently treated biogeoclimatic zones, and the relative management concern for individual wildlife species or species groups.

Subjective data on the management concerns for various wildlife species and species groups were obtained from the B.C. Wildlife Habitat Handbook Problem Analysis (Harcombe 1984), from available regional wildlife plans, and through discussion with the manager of Wildlife Research, MOE Wildlife Branch (D. Eastman, pers. comm., 1986) and other MOE Wildlife Branch biologists.

The likelihood of habitat alteration due to herbicide treatment within biogeoclimatic zones was estimated, based on the assumption that past trends of herbicide use in the various biogeoclimatic zones will continue (see Section 3).

These management concerns and likelihood of alteration variables are presented in a format (Table 9). This table can be used as a guide for determining where herbicide treatments and wildlife habitat conflicts could occur and thus what areas should receive highest research priority.

Key to priorization for Table 9.

N	=	Nil
L	=	Low
M	=	Moderate
H	=	High
VH	=	Very High

VH \ VH	=	Very High	M \ VH			L \ VH			N \ VH		
			VH \ M			L \ H			N \ H	=	Nil
H \ VH			M \ H	=	Moderate	H \ L	=	Low	N \ M		
VH \ H	=	High	H \ M			L \ M					
H \ H			M \ M								

[5] Kimmins, J.P. and T. Simmons. 1980. Research needs into the use of herbicides in forestry in B.C. Unpupl. rep. prepared for Forest Land Use Liaison Committee of B.C.

TABLE 9. Likelihood of herbicide-induced habitat alteration and relative wildlife management concern for specific biogeoclimatic zones[a]

	Biogeoclimatic zone[b]							
	Coastal Western Hemlock	Coastal Douglas-fir	Interior Cedar Hemlock	Interior Douglas-fir	Englemann Spruce-Subalpine fir	Sub-Boreal Spruce	Boreal White & Black Spuce	
	CWH	**CDF**	**ICH**	**IDF**	**ESSF**	**SBS**	**BWBS**	**ANALYSIS AND COMMENTS**
Moose	M[c]\VH[d]	M\H	M\VH	H\M	H\VH	VH\VH	H\H	Very high priority for moose in SBS
Deer	H\VH	H\H	H\VH	H\M	M\VH	L\VH	L\H	High priority for mule deer and white-tailed deer in ICH and black-tailed deer in and CDF
CWH								
Roosevelt elk	H\VH	H\H	N\VH	N\M	N\VH	N\VH	N\H	High priority for Roosevelt Elk in CWH and CDF
Bighorn sheep	L\VH	L\H	L\VH	M\M	L\VH	L\VH	L\H	Moderate priority for sheep research studies in IDF
Grizzly bear	V\H\VH	H\H	H\VH	M\M	H\VH	M\VH	H\H	Very high priority for grizzly bear forage research in CWH
Aquatic and terrestrial furbearers	H\VH	M\H	L\VH	M\M	M\VH	H\VH	M\M	High priority for furbearer studies in the CWH and SBS
Small mammals	M\VH	L\H	L\VH	L\M	L\VH	M\VH	L\H	Moderate priority for small mammal studies in the CWH and\or SBS
Raptorial birds	M\VH	M\H	M\VH	M\M	M\VH	M\VH	M\H	Moderate priority for raptor studies in CWH, CDF, ESSF, and\or SBS
Upland game birds	M\VH	M\H	M\VH	M\M	M\VH	M\VH	M\H	Moderate priority for grouse studies in CWH and ICH
Passerine Birds	H\VH	H\H	L\VH	L\M	L\VH	L\VH	L\H	High priority for forest dwelling birds in CWH and CDF
Amphibians and reptiles	M\VH	M\H	L\VH	M\M	N\VH	N\VH	N\H	Moderate priority for endangered Pacific Giant Salamander and other species of amphibians and reptiles in CWH, CDF, and, IDF

a Key to priorization on preceding page.

b Herbicide use has been negligible in the Coastal Cedars-Pine-Hemlock (CCPH), Spruce-Willow-Birch (SWB), Montane Spruce (MS), Mountain Hemlock (MH), Ponderosa Pine (PP), Bunchgrass (BG) and Alpine Tundra (AT) Zones. Therefore, they have not been considered in the analysis.

c Likelihood of habitat alteration due to herbicide treatment by BGC zone (Based on MOF Stand Tending Records and discussions with forest land managers).

d Relative wildlife management concern of selected species and species groups (Based on Harcombe (1984) and discussions with Regional and Headquarters personnel MOEP, Wildlife Branch).

7.2 Ranked List of Research Topics

The following ranked list of biological research topics reflects the gaps identified by the literature review and the information needs of the MOF Research Branch, CWS, and the MOE Wildlife Branch. The list is relatively consistent with the research priorities presented in Table 9.

Each of the topics indicated should include a comparison of the impact of herbicide-induced habitat changes to the habitat impacts resulting from no action or other alternative vegetation management practices. This would in part answer the question: What are the consequences of not treating a certain habitat with herbicides?.

PRIORITY 1. Moose browse research

The impact of herbicide treatments on the various species of willow and other shrubs important as winter browse to moose should be assessed in the Sub-Boreal Spruce (SBS) Zone. Low-elevation NSR lands and riparian and alluvial habitats should receive the greatest study attention.

The use of herbicides to increase moose browse availability and to enhance the quality and quantity of wildlife food resources should also be evaluated during this proposed investigation.

Any regional and on-site changes to wildlife habitat diversity, species composition, altered use patterns, and changes in diet should also be assessed. As well, the optimum and maximum size of treatment areas should be determined by examining browse availability and seasonal use patterns.

We recommend that a moose browse study, similar to that done by Newton *et al.* (in press) in northeastern Maine, be conducted in conjunction with MOF Silviculture Branch and Research Branch tests of the efficacy of aerially applied herbicides for brushing and weeding or conifer release. Further, we suggest that the Newton *et al.* conclusion that a "combination of early herbicidal release, followed by spacing of conifers by pre-commercial thinning is likely to produce maximum tree growth and most prolonged browse availability in spruce-fir forests," be tested through a long-term integrated (MOF/MOE) study.

PRIORITY 2. Grizzly bear habitat research

The short-and long-term effects should be assessed, of herbicide treatments -- in burn sites, cut-over areas, and other NSR lands within the Coastal Western Hemlock (CWH) -- on berry production and other food resources important to grizzly bear.

This study would be important because of the high degree of management concern for this species, and because of the anticipated increase in herbicide use in the CWH, primarily for salmonberry control. This research could also be conducted in the Englemann Spruce Subalpine Fir (ESSF) and/or Interior Coastal Hemlock (ICH) Zones.

PRIORITY 3. Roosevelt elk browse research

An investigation containing the same components as previously described for the moose browse research (Priority 1) should be conducted in the Coastal Western Hemlock (CWH) Zone of Vancouver Island, to assess the impact of herbicide treatments on forage important to Roosevelt elk.

PRIORITY 4. Small mammal/furbearer research

Research is required to assess the impact of conifer release and chemical (herbicide) brushing and weeding programs on snowshoe hare habitat and population levels; and on other small mammals important as prey species for furbearing mammals, such as lynx, marten, coyote, fox, fisher, and wolf. The impact of herbicide-induced habitat changes on all furbearers should also be assessed. Particular study attention should be given to studying the potential impacts on furbearers using food and cover resources of riparian and alluvial habitats, especially beaver, but also muskrat, otter, and mink. The impact of herbicide treatments on small mammal species, especially bats (habitat and insect prey species) should also be identified through research.

Small mammal research has been initiated in the Coastal Western Hemlock (CWHb1) Zone of northern Vancouver Island, Ritchie *et al.*[6]. A continuation of this research could provide useful information on small mammal population dynamics and small mammal habitat use for herbicide-treated clearcuts. However, small mammal/furbearer research in the Sub-Boreal Spruce (SBS) Zone should also be initiated because this biogeoclimatic zone is very important to the trapping industry.

Research of this type is of high priority because it is a major concern to the B.C. Trappers Association, B.C. Wildlife Federation, and MOE wildlife and habitat resource managers. Furthermore, small mammals are important food sources for other wildlife species such as raptorial birds.

PRIORITY 5. Mule and white-tailed deer browse research

An investigation of the impact of altering the growth and distribution of mule deer and white-tailed deer winter forage following herbicide treatments should be considered in the Interior Cedar Hemlock (ICH) Zone, particularly in the ICHa subzone. Research may also be required for black-tailed deer in the Coastal Western Hemlock (CWH) Zone. Any proposed deer research should address all of the various issues previously outlined in the moose browse research (Priority 1) section.

PRIORITY 6 Forest bird habitat research

The relationships between forest bird communities and herbicide-induced changes to vegetation should be investigated in the Coastal Western Hemlock (CWH) and/or the Coastal Douglas-fir (CDF) Zone.

Detailed information on the vegetation resources and pre-treatment density, diversity, habitat use patterns, and foraging behaviour of birds should be obtained before aerial spraying. The treatment area and a control should be monitored for at least 2 years -- and preferably 4 -- following treatment, to determine any longer-term changes in use.

Pre-and post-treatment quality and quantity of plant-based and insect food resources should also be included in this study, and the importance to birds of untreated leave strips, or patches of vegetation not affected by herbicide, should be determined through research.

The role of forest birds in controlling populations of herbivorous insects (ie. forest pest insects) should be considered as a component of the investigation. Research of this type could generate data which may be useful in the evaluation of the benefits and costs of herbicide treatments and other intensive vegetation management options.

7.3 Additional Research Topics

The following lower priority research topics were also identified during this investigation.

Native grass/ungulate research

The effects of herbicides on native grass species important to elk, bighorn sheep, and other wildlife species should be investigated. The two main grass species that compete with conifers are bluejoint, or marsh reed grass *(Calamagrostis canadensis)* in the Boreal White and Black Spruce (BWBS), Sub-Boreal Spruce (SBS), and Engelmann Spruce-Subalpine Fir (ESSF) Zones; and pinegrass (*Calamagrotis rubescens*), in the Interior Douglas-fir (IDF) Zone (Coates and Haeussler 1986). As these grasses, particularly pinegrass, are also important to livestock on crown range, the MOF Range Management Branch should be encouraged to participate in the investigation (T. Lester, pers. comm., 1986).

Amphibian and reptile research

Information concerning habitat needs, distribution, and abundance of British Columbia amphibians and reptiles is incomplete because of a general lack of research (Sadoway 1986; C. Dodd, pers. comm., 1987). Only the Pacific giant salamander, an amphibian confined to the Chilliwack river

[6] Ritchie et al., 1988.

drainage, has received some attention because of its rarity. Forest-dwelling amphibians are expected to be more at risk than other animals because, in several amphibian species, breathing occurs through the epidermis, and herbicide treatments could be toxic. The direct toxicity question should be relatively easy to answer by exposing experimental animals to various herbicides at a variety of dosage rates in controlled laboratory studies.

8 DISCUSSION OF THE EFFECT OF VEGETATION MANAGEMENT OPTIONS ON WILDLIFE HABITAT

This problem analysis contains a review of existing information, and outlines the concerns of British Columbia resource managers to the impact of silvicultural herbicide treatments on the habitat and forage resources of several wildlife species and species groups. Additional ecological research is required to address these impacts adequately. However, co-operative research to determine wildlife habitat impacts associated with other vegetation management practices is also necessary, because most forest vegetation management activities cause alterations to habitats at the early and mid seral stages of the rotation.

The habitat impacts associated with the use and timing of two or more vegetation management practices applied in combination should also be determined through research. Such combinations of techniques may be required to obtain control of competing vegetation on some advanced cut-over sites (Newton and Roberts 1979). Thus, future research studies should be designed to generate information on habitat responses not only to single vegetation management options, but to a combination of treatments. For example, the use of herbicides followed by pre-commercial thinning of conifers was found to produce both maximum coniferous tree growth and prolonged moose browse availability in several advanced cut-over sites in Maine (Newton *et al.*, in press). Similar research in British Columbia forests could probably provide valuable information on the use of vegetation management techniques to enhance wildlife habitats, thus meeting both regional wildlife management objectives and silvicultural policy goals.

Approximately 200 000 ha of forest lands in British Columbia are annually disturbed by timber harvesting and wildfire. These two disturbances are responsible for significant changes in wildlife use patterns resulting from alterations in the structure of the habitat or loss of plant communities. In this regard, the habitat relationships and life requisites of game and non-game wildlife species in British Columbia are currently being identified through a co-operative project sponsored by the MOE and MOF (A. Harcombe, pers. comm., 1987). B.C. Wildlife Habitat Handbooks produced through this project will provide valuable information for predicting the response of wildlife after vegetation management, timber harvesting, and other disturbances. This information will serve as a basis for determining the quality and quantity of habitat lost or formed each year in managed forests, and will help place the impacts of vegetation management treatments on wildlife habitat in a regional and Provincial perspective.

The need for this type of logical, step-wise research is supported by Morrison and Meslow (1983), who suggest that the importance of what the various physical and biological components of habitat mean for individual wildlife species must first be determined. Then, research to determine how herbicides affect these biological and physical components of the habitat must be conducted. They suggest that the final step in the procedure should be the assessment of short-and long-term impacts of this habitat change on local, regional, and provincial animal populations. The B.C. Habitat Handbook project should provide the first step, and the research identified in this problem analysis will represent the second. The last step in the procedure will have to be jointly undertaken by B.C. wildlife and forest resource managers, if the objectives of integrated forest land management are to be achieved.

The communications, extension, and technology transfer (education) research needs identified by several of the forest and wildlife habitat resource managers in the province are also important. However, identification of these non-biological research topics is considered to be beyond the scope of this investigation.

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APPENDIX 1 List of individuals interviewed in person and/or by telephone

Ackerman, Gordon	(MOF, Victoria)
Adams, Rob	(MOE, Victoria)
Archibald, Ralph	(MOE, Victoria)
Arthur, Bill	(MOE, Prince George)
Beatty, Julia	(MOE, Victoria)
Beaumont, R.W.	(Weldwood, Vancouver)
Beese, Bill	(M&B, Nanaimo)
Beets, Marty	(MOE, Williams Lake)
Belz, Doug	(DNR, Olympia)
Bengston, George	(OSU, Corvallis)
Blackstock, Mike	(MOF, Victoria)
Boateng, Jacob	(MOF, Victoria)
Campbell, Dan	(USFWS, Olympia)
Chambers, Al	(UBC and B.C. Wildlife Fed., Vancouver)
Conard, Susan	(USDA, Riverside, California)
Coombs, Wayne	(CFS, Victoria)
Crocker-Davis, Pam	(National Audubon Society, Olympia)
Cronin, Dan	(MOE, Victoria)
deCalesta, David	(OSU, Corvallis)
Dodd, Chris	(MOE, Victoria)
Eastman, Don	(MOE, Victoria)
Edie, Al	(MOE, Smithers)
Ellis, Rick	(MOF, Victoria)
Evans, Jim	(USFWS, Olympia)
Fraser, Dave	(U.VIC., Victoria)
Grier, Norma	(NCAP, Eugene)
Haley, Dave	(MOF, Victoria)
Harcombe, Andrew	(MOE, Victoria)
Harper, Fred	(MOE, Fort. St. John)
Hatter, Jim	(BCTA, Guide/Outfitter, Victoria)
Henigman, John	(MOF, Victoria)
Herbison, Brenda	(B.C. Wildlife Fed., Argenta)
Herring, Les	(MOF, Prince George)
Inkpen, Wayne	(Alberta Fish and Wildlife, Edmonton)
Johnson, Charlie	(MOF, Victoria)
Johnson, John	(Crown Forest Industries, New Westminster)
Khan, Insha	(MOF, Victoria)
Kimmins, Hammish	(UBC, Vancouver)
King, Dave	(MOE, Prince George)
Krumlik, George	(MOF, Victoria)

Langin, Herb	(MOE, Williams Lake)
Larsen, Gary	(USDA, Portland)
Lauterbach, Paul	(Weyerhauser consultant, Tacoma)
Lea, Ted	(MOE, Victoria)
Lester, Tom	(MOF, Victoria)
Little, Bob	(MOE, Smithers)
MacKinnon, Gordon	(MOE, Penticton)
Mansell, John	(Weldwood, Williams Lake)
Moore, Duanne	(OSU, Corvallis)
Newton, Mike	(OSU, Corvallis)
O'Brien, Mary	(NCAP, Eugene)
Pamplin, Bruce	(MOF, Prince George)
Perry, David	(OSU, Corvallis)
Piggin, Dave	(MOF, Victoria)
Poelker, Richard	(Game Commission, Olympia)
Pollack, John	(MOF, Smithers)
Quaedvlieg, Robert	(BCTA, Mackenzie)
Roddick, Rene	(BCHA, Vancouver)
Sadoway, Karen	(MOF, Victoria)
Saunders, Barry	(MOE, Victoria)
Schafer, Mike	(USDA, Portland)
Sharp, Wayne	(BCTA, Prince George)
Trethewey, Don	(CWS, Vancouver)
van Drimmelin, Ben	(MOE, Smithers)
Vold, Terje	(MOE, Victoria)
von Schuckmann, Sylvia	(MOE, Queen Charlotte City)
Vyse, Alan	(MOF, Kamloops)
Wan, Mike	(EPS, Vancouver)
Watts, Sue	(UBC, Vancouver)
Wetmore, Steve	(CWS, Vancouver)
Whitehead, Phil	(CWS, Vancouver)
Whitehead, Roger	(CFS, Victoria)
Willington, Bob	(BC Forest Products, Crofton)
Wyeth, Mike	(MOF, Victoria)
Youds, John	(MOE, Williams Lake)